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Title: Effects of Surface Energy on Adhesive Strength of Sylgard

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Effects of Surface Energy on Adhesive Strength of Sylgard

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8/3/2021

LA-UR

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Introduction

- Previous tests showed large variation in measured separation load.
- Large variation may be attributed to the surface preparation.
- The following experimental variables will be more closely controlled:
 - Component tolerances
 - Assembly procedures
 - Diagnostics
 - Surface preparation
- Surface preparation will be characterized by measuring the free surface energy of the adherents prior to sample assembly.

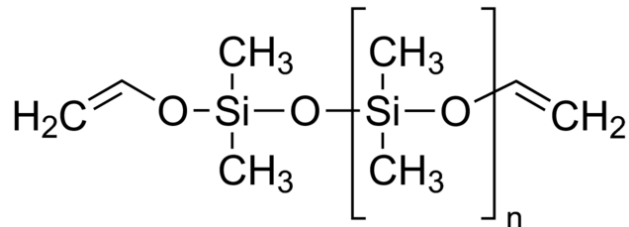
Objective

1. Determine the cause of significant variation in measured Sylgard adhesive strength.
2. Calibrate a traction-separation finite element model.

Background

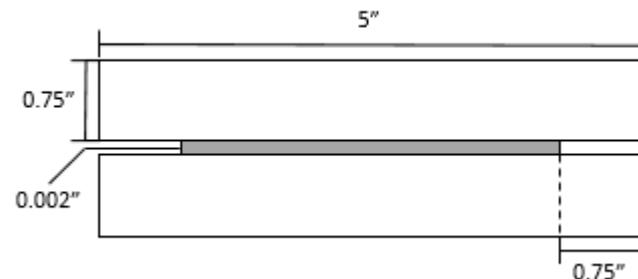
Sylgard 184

- Nonflammable, transparent encapsulant.
- Flowable material during application.
- Flexible elastomer once cured.
- Typically used for electronic application protection.
- Sylgard 184 95/5:
 - 95% polymer base
 - 5% curing agent



Double Cantilever Beam Testing

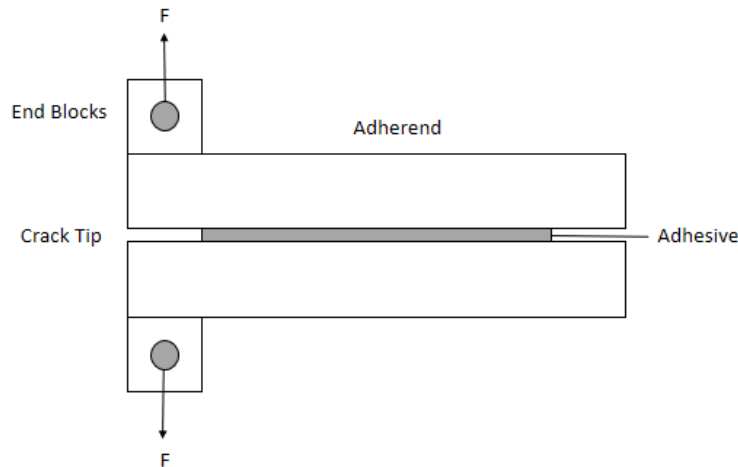
- Most common method to measure Mode I fracture toughness in 1D.
- Specimens made of aluminum.
 - Length= 5 in
 - Width= 0.75 in
 - Thickness= 0.25 in
- Pulled perpendicular to the length (y-direction).



Background

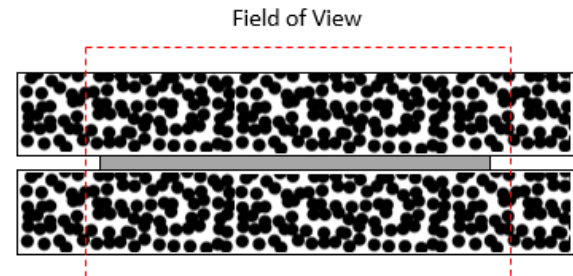
Mode I (Opening Mode)

- Only considers tensile stress.
- Only stress in y-direction is of interest.
- Stress in x-direction insignificant in comparison.



Digital Image Correlation

- Non-contact optical technique.
- Can be used to calculate different properties, including:
 - Displacement
 - Strain
 - Strain rates
 - Velocity
- Measures evolving 2D or 3D coordinates.



Background

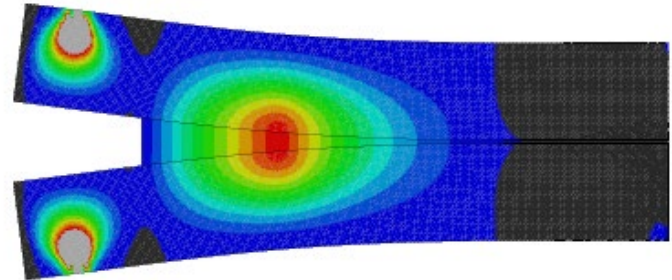
Surface Analyst

- Non-destructive, handheld inspection device.
- Measures contact angle of water.
- Water contact angle is correlated to surface energy (calibration curve).



Abaqus/CAE

- Computer-aided engineering (CAE).
- Software for finite element analysis.
- Create, edit, monitor, diagnose, and visualize advanced analyses.
- Intuitive and easy to use.
- Integrates modeling, analysis, and visual results.



Experimental Methods

- Sample preparation will be strongly controlled.
- During preparation surface angles of adherends will be measured.
- Surface energy will be determined.
- 10 specimens will be tested using 2-D DIC (one camera used)
 - 5 will be prepped using only isopropanol.
 - 5 will be sanded and cleaned with isopropanol.
- Samples will be fixed to the load frame.
- All tests will be tested using Mode I (theta equal to 0)
- Tests will be conducted at quasi-static rates (0.03 mm/min)
- Displacement and applied load will be measured.



Computational Methods

- Experimental data collected will be used to calibrate a traction separation finite element model using Abaqus.
- Plane stress model (loading and response in x-y plane)
- More accurate parameters (mean values) will be developed based on test results.
- Parameters include:
 - Peak normal traction (σ^p , MPa)
 - Elastic stiffness (K_{nn} , MPa/mm)
 - Critical energy release rate (G_c , mJ/mm²)

Expected Results

- It is expected that the results will show a direct correlation between surface energy and the adhesive properties of Sylgard.
- Surface energy will show that it is a direct result of surface preparation.
- Stronger surface preparation control will significantly reduce the standard deviation previously found.
- Larger population will provide a normal distribution for the data.
- Different surface energies will further prove the correlation between surface energy and adhesive properties.

References

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Questions?